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Design of a problem-based curriculum: a general approach and a case study in the domain of public health

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SUMMARY *A general approach to curriculum design in the context of Problem-Based Learning (PBL) is outlined. Ten general 'steps' for problem-based curriculum development are proposed, using the case study methodology to describe the underlying iterative process. Examples are given from the case of the development of a public health professions education curriculum. The process starts with defining the purpose of the curriculum. General objectives are generated in a top-down fashion. The prior knowledge, skills and misconceptions of future students are considered. A preliminary schedule of the curriculum is developed, including sketches of unit blueprints. These are further elaborated. Unit subgoals are related to planned educational activities. Only then, are the learning materials created, with problem writing as the most important aspect. In developing a problem-based curriculum, assessment deserves special attention, because of its influence on the learning process. Finally, educational organization, curriculum management and evaluation procedures are considered.*

Introduction

Problem-based learning (PBL) has been among the curricular innovations most discussed in higher education over the last 30 years. Several studies have shown that PBL is a successful approach compared with more traditional curricula with regard to intrinsic motivation (e.g. Blumberg & Michael, 1992) and long-term retention of learned knowledge (e.g. Norman & Schmidt, 1992). During this period, our understanding of the processes underlying PBL has grown. Empirical studies have shown, for instance, that the activation of prior knowledge through small-group discussions plays an important role in facilitating further learning, that intrinsic motivation is an inherent aspect of learning in a problem-based context, and that tutors must have both a personal interest in their students' learning and sufficient subject-matter expertise to guide their students' learning effectively (Schmidt & Moust, 2000).

Less is known, however, about the processes that guide the design of problem-based curricula and courses (Snellen-Balendong, 1993; Schmidt & Moust, 1999). In this article a general approach to problem-based curriculum design is outlined. Although ample descriptive literature exists on curriculum development in general as well as on general aspects of PBL, we believe there is a need for a more specific description of the design of problem based-curricula. By providing a sufficiently detailed description of this process, we hope to contribute to a deeper understanding of problem-based curriculum development and to provide general guidelines for the problem-based curriculum development in a variety of settings.

The scientific approach followed to describe the process is the case study method (Goodwin, 1995). The case concerns the development of a PBL curriculum at the School of Public Health (ESP: Escola de Saúde Pública) of the state of Ceará, Brazil. The curriculum involved was a specialization course for health professionals on epidemiological surveillance. The case used is somewhat atypical: most descriptions of PBL have used examples from four- or five-year curricula developed mostly in North American or European universities. The present case concerns the development of a one-year part-time course for health professionals working in the field of epidemiological surveillance in Ceará (a relatively poor state in the North East of Brazil with seven million inhabitants). We describe how the application of the general model of problem-based curriculum development works in this special case. In addition, we will indicate how the process differs from the development of a longer curriculum based on our experiences at Maastricht University.

In the general literature on curriculum development, Tyler (1949) proposed that four fundamental questions have to be answered in developing a curriculum: (1) What is the purpose of the curriculum? (2) What educational experiences can be provided to attain these purposes? (3) How can these educational experiences be organized effectively? (4) How can we determine whether these purposes are being attained? These general questions return in more recent general publications on curriculum design (e.g. Harden, 1986; Pratt, 1980; Posner & Rudnitsky, 1997; Ten Cate, 1998).

We propose 10 general steps for the design of a *problem-based curriculum*, hence an adaptation of the general guidelines as given by Tyler and others to the case of designing a PBL curriculum. The ten 'steps' are presented in Table 1. Although the term 'steps' and the presentation as a sequence could easily create the impression that the

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Table 1. Ten general steps of curriculum design in problem-based learning (PBL)

1. Give the rationale for the curriculum and form a curriculum planning group
2. Generate general educational objectives of the curriculum
3. Assess the educational needs of future students
4. Apply the educational principles of PBL to the curriculum
5. Structure the curriculum and generate a curriculum blueprint
6. Elaborate the unit blueprints
7. Construct the units
8. Decide on student assessment methods
9. Consider the educational organization and curriculum management
10. Evaluate the curriculum and revise it (when necessary)

underlying process is linear, this is not the case. As will be shown, many of the steps are related and many drafts are needed in the design process, because later steps feed back into earlier steps taken. Curriculum design is essentially an *iterative process*.

Before describing the process of problem-based curriculum design, it should be noted that the present paper does not address the choice of developing a problem-based or other type of curriculum (see for example Norman & Schmidt, 1992). There are different possibilities with regard to the development of a problem-based curriculum: an educational institution may decide to develop only problem-based curricula (both ESP and Maastricht University), it may develop both problem-based and other curricula for different subjects, or it may develop parallel tracks, allowing the students to choose between a problem-based or a traditional curriculum. The approach described is applicable when it has been decided to develop a problem-based curriculum.

Step 1: Give the rationale for the curriculum and form a curriculum-planning group

In this step, the following question needs to be answered: what makes the development of this particular curriculum in this school necessary? Answering this question is important, because it explicates why the whole exercise is undertaken; it is the *raison d'être* of this curriculum. This may be based on needs of future students and society. When it is decided that a new curriculum has to be developed, a curriculum-planning group is installed. This group consists of three to eight people from different backgrounds, preferably including both educational and content experts and future teachers of the new curriculum. An important first task for a curriculum-planning group is to agree on the approach taken to curriculum development and on a time schedule for this process.

In the present case, the development of the curriculum on Epidemiological Surveillance was a response to changes in Brazil's healthcare system. Until recently, surveillance of the potential outbreak of epidemics was done at the central level of each of the 27 states of the federal republic. When, for instance, a case of meningitis was reported in a remote village, a representative from the state capital had to come down to that village. It was decided at government-level to decentralize these surveillance activities to the 'municipalities' (cities or clusters of villages). This decision generated the need for professionals who could act as field epidemiologists. Since no suitable curriculum existed in the state of Ceará, a new curriculum had to be developed targeting people already working in the field. The ESP received the assignment to develop this curriculum from the state government. Once curriculum development began, two external consultants were added to the curriculum planning group: a content-expert and an educational consultant.[1] The present approach to problem-based curriculum design and a time schedule were agreed upon: in the two weeks of the consultations, the primary goal was to generate an outline of the whole curriculum. Specific units could be filled in later by the ESP members of the curriculum-planning group. In order to facilitate this, at least one unit was to be worked out during this period.

Step 2: Generate general educational objectives of the curriculum

A generally accepted starting point for the development of a problem-based curriculum is the set of professional competences of future graduates, which describe the typical problems professionals have to deal with (Bouhuijs *et al.*, 1993). Various sources of information may be used to define the typical problems, such as: a task analysis, interviews with experts in the field and organizing focus groups with stakeholders. Once the typical problems are identified, these have to be 'translated' into general educational objectives, such as intended competences and knowledge of future students. In this 'translation process', reviewing the literature and consulting both content and educational experts is useful. An explicit description of the curriculum's educational objectives serves several goals: they serve as a starting point in the process of curriculum design, and they may help both future students and employers to know what to expect from the curriculum.

In the present case, the societal need of a changing health system had to be translated into a set of educational objectives. General objectives were generated as described above. To facilitate the process of prioritizing these objectives, each objective received a rating on two dimensions: importance and expected difficulty, ranging from 1 to 5 (the highest score). These ratings are important for deciding what to include in the curriculum and what to exclude and they are also helpful for the later structuring process (Step 5). Examples can be found in Table 2.

Step 3: Assess the educational needs of the future students

In this step, the educational needs of future students should be carefully considered, in a process called 'needs

Table 2. Example objectives from the epidemiological surveillance curriculum

Objectives	Importance	Difficulty
• Analyze the epidemiological situation in the municipality, micro-region (a cluster of municipalities), and state	3	4
• Know the clinical, epidemiological and laboratory aspects of diseases and illnesses for which surveillance should take place	5	3
• Correctly use the epidemiological information system	3	5
• Monitor illnesses	3	2
• Carry out epidemiological investigations	4	3
• Plan and implement control measures	4	3
• Maintain a system to communicate epidemiological information to the public and to health services	1	3.5
• Carry out epidemiological research	1	5
• Carry out health education activities related to health problems of epidemiological importance to the region.	2	3.5

Note: 1 = very easy/not important; 5 = very difficult/very important

assessment' (see Atwood & Ellis, 1971). In this process, the general educational objectives generated in step 2 are compared with the expected prior knowledge of future students. Selection criteria and recruitment strategies for future students can be discussed (e.g. requested level of prior education). Several sources can be used to assess educational needs: interviews or surveys with potential students, direct observation of actual or simulated performances and focus groups with specialists and employers. These data are then analysed to identify 'true' educational needs (knowledge, skills, and attitudes) and 'other' needs (e.g. lack of infrastructure). Although (professional) education is usually focused on true needs, the assessment of other needs may be helpful to optimize future professional performance.

It may be useful to differentiate between *two types* of true educational needs: students may *lack* certain knowledge or skills (e.g. do not know how to work with an important computer program), and students may have *wrong* ideas ('misconceptions') or bad skills that need to be replaced by better ones. The cognitive literature has shown that misconceptions can be coherently organized into 'naïve theories' that are resistant to change and may interfere with the educational process (McCloskey, 1983; Chinn & Brewer, 1993; Samarapungavan & Wiers, 1997). Considering misconceptions can be useful both at this step and in problem writing (step 7).

In the present case, the target group of future students consisted of professionals working in the departments of epidemiological surveillance in the 21 micro-regions of the state of Ceará, working in local health authorities or in the State Health Secretariat. Most future students were expected to be nurses with good clinical skills, but with relatively poor knowledge and skills in the field of epidemiology. It was judged uncertain whether the importance of maintaining the epidemiological information systems was well understood and whether there were misconceptions regarding these systems. Necessary general computer skills and more specific skills of data analysis and quality control were expected to be variable and often lacking. In line with the assignment, it was decided that the curriculum would be accessible to all professionals currently working in the field (with no further selection regarding prior education). The educational needs had been assessed by interviewing professionals working in the field of epidemiological surveillance and by organizing group discussions with representatives of local and state health authorities. In the curriculum-planning group, these needs were elaborated upon. This step should be reconsidered after evaluative feedback from the first students (step 10), in case important educational needs have not been addressed in the curriculum.

Step 4: Apply the educational principles of PBL to the curriculum

It is important for an educational institution to realize that the introduction of a problem-based curriculum has implications at all levels of organization. Here we will point to some aspects of PBL that are directly relevant for curriculum design (for a more general overviews of PBL, see Bouhuijs *et al.*, 1993):

- Education is organized in thematically organized multidisciplinary *units*. The themes of the units are often related to real-world problems professionals have to deal with.
- Tutorial groups (small discussion groups) and self-study are the core of the PBL curriculum. In these groups the 'problems' are discussed and learning objectives are generated that guide subsequent self-study. This has implications for scheduling, organization and necessary facilities (e.g. the presence of many 'discussion rooms').
- Unit books guide students through the unit. A unit book contains all practical information for that unit and the 'problems' (see step 7).
- Other study activities may complement the tutorial groups, such as lectures, a practical or skills training.

These general aspects of PBL should be thoroughly discussed before a school embarks on the endeavour of constructing the necessary curricular materials. In addition, the size of the curriculum's student population should be considered: you must have enough facilities and staff to carry out the educational activities planned. Note that the staff:student ratio is higher in PBL than in conventional education.

In the present case, the ESP already employed PBL as a general educational approach to all curricula. Therefore, these general aspects of PBL were already accommodated in the organization of the school. With regard to the development of the present curriculum, the importance of integrating practical skills training and knowledge development was emphasized. Integration of the learning materials into the current working field was judged particularly important. It was decided to aim for this curriculum at 30 students a year, which would serve the needs in the region and be feasible for the staff of the ESP (about 20 instructors would be involved).

Step 5: Structure the curriculum and generate a curriculum blueprint

In this core step of problem-based curriculum development, the information from the previous steps has to be integrated into a preliminary curriculum blueprint. In case of the development of a longer curriculum, it can be useful to first divide the curriculum into phases (for example study years, or a 'theory phase' followed by a 'practice phase'; Snellen-Balendong, 1993). In a longer curriculum, the structuring process described first takes place at the more general level and is then repeated at the level of the different phases.

In the process of translating the general educational objectives into a curriculum blueprint, several issues have to be considered:

(1) *The structure of the educational building blocks ('units')*. In PBL, a vertical structure usually dominates. This implies that the core of the curriculum consists of a sequence of units in which contributions of different disciplines are integrated. One may decide to adjust the length of these units to the particular contents of a unit or to have units of a fixed length (which has the advantage that they can be rescheduled more easily). In addition, one may choose to have a horizontal component next to the vertical unit structure (a 'parallel programme'). This has the potential disadvantage that requirements for the units and the parallel programme interfere. However, for skill-development, this organizational format can have advantages.

(2) *Both the (multidisciplinary) contents of a unit and an overarching theme have to be identified for each unit*. These two choices are related and one may choose to start with one or the other. With regard to possible themes, it may be useful to make a concept map of the core concepts in the curriculum (or phase). For example, in a phase in a medical curriculum focusing on the human body, various body systems can be used to generate block themes (Snellen-Balendong, 1993). Once the themes are generated, the multidisciplinary curriculum-planning group can consider potential contributions of different disciplines.

(3) *The sequence of units should be considered*. In this phase of the process, preliminary sketches of unit blueprints are produced, describing for each unit the global subject description, the educational objectives, and the relations to other units and the disciplines involved. Note that there is no one-to-one relation between general objectives and units, because units are thematically organized. During this part of the process, many drafts are produced.

In the present case, the development of practical experience with the health information systems was judged to be a crucial general objective of the curriculum and a necessary prerequisite for mastering the other objectives. 'Health information systems' includes topics such as data collection and data analysis, and decision making in epidemiological surveillance. It was decided that the students should first focus on the importance of the information system (the '*why*' question), followed in later units by a further development of the skill of working with the information system (the '*how*' question). Practical training with the information systems was introduced as a 'parallel' unit, relating to the contents of units 2 to 5. Further, it was judged desirable to change the school's usual time schedule (a long weekend every other week) to one full study week per month. In this way, it was expected that a more integrated learning process could take place relating content-matter and practical skills. In addition to these intensive weeks, take-home 'field assignments' would be given to let students apply the newly acquired knowledge and skills in their own working environment. This would also help to bridge the relatively long period between the educational weeks. As an indication, each unit would start with a discussion of the take-home field assignment of the previous unit, and end with a new take-home field assignment. Finally, it was judged desirable to start the curriculum with an introductory unit, in which the educational method (PBL) was motivated and practised, and a general introduction to the whole curriculum was given. Table 3 displays the outcome of this part of the problem-based curriculum design process (after many drafts).

Step 6: Elaborate the unit blueprints

When the global structure of the curriculum has been defined, the units can be described in more detail. The short first sketch of the unit blueprint that is part of the curriculum scheme (Table 3) serves as a starting point for

Table 3. Structure of the curriculum on epidemiological surveillance

Unit	Name	Number of weeks	Parallel programme
1	Introduction to PBL and to the curriculum	1	
2	Dengue fever An introduction to epidemiological surveillance	1	Health information systems
3	Planning and decision making	2	Health information systems
4	Processes of epidemiological surveillance	3	Health information systems
5	Health education and communication	2	Health information systems
6	Conclusion, final exam	1	Health information systems

further elaboration of the unit blueprint. The curriculum-planning group should give enough structure to the unit-planning group to further construct the unit (step 7), while avoiding that the creative process of the unit-planning group is hindered. In a brainstorming session, a list of more specific educational subgoals is generated for each unit. As in step 5, a concept map or topic tree may be helpful. For a more detailed description of the process of elaborating the unit blueprint, see Snellen-Balendong & Dolmans (1999).

In the present case, the second unit was chosen as an example for further elaboration of other units. The general learning objective for this unit was to provide an introduction to epidemiological surveillance. This unit should also introduce the students to the information systems. From these general objectives, more specific subgoals were generated: (1) understand the differences between passive and active surveillance; (2) understand the importance of epidemiological surveillance as a continuous process; (3) relate biological processes or specific diseases to the aspects of the information systems necessary for the effective control of that disease; and (4) understand the influence that the type of surveillance has on the interpretation of data. A general theme for this unit had been generated in step 5: 'Dengue Fever'. A unit blueprint was composed, again after some drafts.

Step 7: Construct the units

When the units are actually constructed (or reconstructed in case of a revision of an existing curriculum), a unit-planning group is formed. For each unit, a planning group usually consists of a coordinator, two to three staff members and a student representative. Once the unit-planning group is formed, the actual learning materials are developed. The unit-planning group usually starts with a discussion of the problems that have to be written, based on the specific educational objectives outlined in the unit blueprint (generated in step 6).

For each problem, the type of problem is discussed (see Schmidt & Moust, 1999) and relevant literature is selected. Ideas for problem writing are generated through brainstorming with the unit-planning group. Here, the anticipated prior knowledge and misconceptions of students are particularly relevant. One or two members of the unit-planning group write the draft versions of the problems. The draft problems are discussed critically by the planning group and—if possible—tested by presenting them to a representative group of students. Further guidelines for problem design can be found in Dolmans & Snellen-Balendong (1999).

The unit construction is finalized by planning and scheduling the other educational activities (e.g. an overview lecture, a skills training session) and writing the unit book and the tutor version ('tutor guide') of the unit book. In addition to the problems, the unit book contains general information concerning the unit, such as attendance regulations, contact persons, methods of assessment and learning resources (e.g. references). It is helpful for both students and staff to use a standard format for all unit books. The tutor guide describes the type of problem, the learning objectives, summaries of the issues that should be discussed, students' prior knowledge and expected misconceptions, expected difficulties in problem discussion, and suggestions for tutor reactions and summaries of the relevant literature. A detailed tutor guide is important both for theoretical reasons (important determinant of learning outcomes, Schmidt & Moust, 2000) and for practical reasons (more easy to fit in new tutors).

The curriculum here was relatively short, which made the differentiation between the curriculum-planning group and the unit-planning group less absolute than in longer curricula. Here, most members of the curriculum-planning group joined the unit-planning group to develop the example unit. In the development of longer curricula, good communication between the curriculum- and the unit-planning groups is important and not always easy to achieve. Problem writing was done as described above. At a later stage, more problems were written and optimized after testing with a group of students.

Step 8: Decide on student assessment methods

Student assessment is an important aspect of curriculum design, especially in PBL. The reason is that assessment should reward the study behaviour that is expected from students in a problem-based curriculum. Students easily give up their own learning goals when they notice that they are 'punished' for this strategy in the examination. Student assessment methods in problem-based curricula have to comply with the following general principles: (1) provide opportunity for the students to show what they have learned rather than what the teacher thinks they should have learned; (2) provide opportunities to apply the acquired knowledge; (3) contextual assessment is particularly suited, preferably in the form of a concrete problem directly linked to a professional situation. Assessment methods that partially fulfil these requirements are (short) essays, take-home assignments, skills assessments and the progress tests (see Van Berkel *et al.*, 1994). For further suggestions regarding assessment in problem-based settings see Nendaz & Tekian (1999). In addition to student assessment, general regulations should be formulated concerning required attendance (usually high in PBL) and extra assignments when attendance regulations are not met.

In the present case, it was decided to use a number of contextual problems in the assessment similar to the ones discussed and studied during the unit. Students would have to explain these problems in terms of underlying principles, and describe procedures that could lead to a resolution. A second type of assessment that was judged useful was the field assignment at the end of each study week. It was sugested that marks could add up over subsequent assignments, which would encourage students to work regularly and apply their new knowledge and skills in their own situation. With regard to required attendance, it was decided that this should be at least 75%, with extra assignments given to students who do not meet this criterion.

Step 9: Consider the educational organization and curriculum management

Problem-based curricula with their multidisciplinary emphasis require special forms of organization. Members

from different departments have to collaborate in the design of the units and in the educational activities that take place during the unit. Taking the final responsibility for the curriculum from the departments to a central level of decision making is thought to be crucial for the success of problem-based curriculum development (see further, Bouhuijs *et al.*, 1993). A problem-based curriculum requires special measures for proper management. The central question is how to organize curriculum development, maintenance and improvement. Good communication between the central curriculum management and staff-member unit-planning groups is essential. One way to organize this in longer curricula is by regular meetings of 'curriculum year groups', consisting of the unit coordinators of the different units of an educational year (Maastricht University). Further, PBL requires intensive faculty training (see Des Marchais & Chamberland, 2000).

Here, educational organization and curriculum management were discussed in general terms with the ESP management. Since PBL was already the general educational approach, most organizational requirements were already present. One aspect of the organization that was discussed more extensively was whether the educational responsibilities should be delegated to specific unit planning groups with a unit coordinator, or at the level of the one-year curricula (the responsibility of one person).

Step 10: Evaluate the curriculum and revise it (when necessary)

The goal of evaluation is primarily to improve next year's curriculum. Different sources of information can be used:

(1) *Students*. For the revision of the curriculum it is helpful to have students' judgements of educational activities (at the level of the curriculum as a whole, at the level of units and at a more detailed level, including specific problems, lectures, training, etc.). This provides priorities for the revision process (for a PBL evaluation form see Schmidt *et al.*, 1995).
(2) *Tutors*. Tutors are a very good source of information regarding the quality of problems. The standard evaluation form for students can easily be adapted for use with the tutors, with emphasis on the quality of the problems, the tutor instruction and the amount of 'steering' that was needed, for each problem.
(3) '*Society*'. This involves an evaluation of the curriculum's more general objectives (step 2). Did the curriculum succeed in making health professionals do their job better? This question can be asked of alumni, and of their colleagues or other professionals in the field. In addition, shortcomings and needs for changes in the curriculum can be assessed. The information gained from students and tutors is used in revising both the curriculum as a whole and specific units. For an example of an evaluation procedure in a problem-based curriculum, see Dolmans *et al.* (1997).

In the present case, a new curriculum was developed. Therefore, the evaluation strategies mentioned were discussed in general terms and will be applied when possible. In addition, the ESP has a tradition of asking future employers of their students how well they apply the acquired knowledge and skills in their professional environment. The outcomes of this prospective evaluation will be discussed with the state ministry of health, who assigned this new curriculum.

Conclusion

In this paper we have described a general approach to curriculum development in a PBL context, using the development of a problem-based curriculum in health professions education as a case study. This description served two purposes: it aimed at describing the underlying process and could be helpful for future problem-based curriculum development. This was considered important because descriptions of this kind are generally lacking in the literature: there are general descriptions of PBL and of curriculum development but not of the combination of the two. The description demonstrated that problem-based curriculum development is a dynamic process with many interrelated steps. The 10 steps described here could be applied to the specific needs of problem-based curriculum development in a particular context, ranging from the development of a relatively short health professions education curriculum (the central case here) to the development of the more typical long curricula in universities.

Practice points

- Problem-based curriculum design is an iterative process, described here in 10 steps.
- The organization of the curriculum should first be considered, before the actual learning materials are developed.
- When learning materials are developed, earlier steps guide the types of problems that should be developed, the choice of additional educational activities and their scheduling and organization.

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Note

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